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1. REPORT DATE (DD-MM-YYYY) 30-01-2019		2. REPORT TYPE Final Report		3. DATES COVERED (From - To) 21-Aug-2015 - 20-Aug-2018	
4. TITLE AND SUBTITLE Final Report: Properties of Solution-Processed and Vapor-Grown 2D-Layered Materials and Heterostructures				5a. CONTRACT NUMBER W911NF-15-1-0425	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER 106012	
				5d. PROJECT NUMBER	
6. AUTHORS				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAMES AND ADDRESSES University of Texas at El Paso 500 West University Avenue Administration Building, Room 209 El Paso, TX 79968 -0587				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211				10. SPONSOR/MONITOR'S ACRONYM(S) ARO	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) 67216-MS-REP.6	
12. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			Anupama Kaul
			UU		19b. TELEPHONE NUMBER 915-747-6003

**RPPR Final Report**  
as of 31-Jan-2019

Agency Code:

Proposal Number: 67216MSREP  
**INVESTIGATOR(S):**

**Agreement Number: W911NF-15-1-0425**

**Name:** Anupama B. Kaul  
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EIN: 746000813

**Report Date:** 20-Nov-2018

Date Received: 30-Jan-2019

**Final Report** for Period Beginning 21-Aug-2015 and Ending 20-Aug-2018

**Title:** Properties of Solution-Processed and Vapor-Grown 2D-Layered Materials and Heterostructures

**Begin Performance Period:** 21-Aug-2015

**End Performance Period:** 20-Aug-2018

**Report Term:** 0-Other

Submitted By: Luis Garcia

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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**STEM Degrees:** 0

**STEM Participants:** 0

**Major Goals:** see uploaded report under upload section.

**Accomplishments:** see uploaded report under upload section.

**Training Opportunities:** Nothing to Report

**Results Dissemination:** Nothing to Report

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

**PARTICIPANTS:**

**Participant Type:** Graduate Student (research assistant)

**Participant:** Carlos Francisco De Anda Orea

**Person Months Worked:** 4.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Jay Amrith Desai

**Person Months Worked:** 12.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

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Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Ridwan Hossain Fayaz

**Person Months Worked:** 5.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** PD/PI

**Participant:** Anupama Kaul

**Person Months Worked:** 1.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Gustavo Alberto Lara Saenz

**Person Months Worked:** 5.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Participant:** Misook Min

**Person Months Worked:** 5.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Participant:** Nirmal Adhikari

**Person Months Worked:** 1.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Avra Sankar Bandyopadhyay

**Person Months Worked:** 5.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

**RPPR Final Report**  
as of 31-Jan-2019

National Academy Member: N  
Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Jorge A Catalan Gonzalez

**Person Months Worked:** 4.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Srishti Chugh

**Person Months Worked:** 12.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Dr. Kaul moved from the University of Texas, El Paso (UTEP) to the University of North Texas (UNT) in the Fall of 2017 and continued to advise students at UTEP in her absence toward meeting the research goals of this project. The research outputs emerging from this grant are noted below. The Kaul group is grateful to the support received from Dr. Pani Varanasi's program at the ARO, and also to UTEP Engineering Dean, whose assistance has been invaluable during the transition process.

## **PUBLICATIONS**

### **JOURNAL (published and/or in review)**

1. A. Delgado, J. A. Catalan, H. Yamaguchi, C. N. Villarrubia, A. D. Mohite, and A. B. Kaul, "Opto-electro-mechanical percolative composites from 2D layered materials: properties and applications in strain sensing," manuscript in preparation, to be submitted.
2. J. Desai, S. Chugh, and A. B. Kaul, "Highly conductive, ink-jet printed graphene and WS<sub>2</sub> inks scalable over large areas," submitted (in review).
3. S. Chugh, N. Adhikari, J. Lee, D. Berman, L. Echegoyen, and A. B. Kaul, "Dramatic enhancement of optoelectronic properties of electrophoretically deposited C<sub>60</sub>-graphene hybrids," to be submitted.
4. J. Desai, N. Adhikari, A. S. Bandyopadhyay, and A. B. Kaul, "High photoresponsivity in an all ink-jet printed heterostructure WS<sub>2</sub>-graphene photodetector," manuscript in preparation, to be submitted.
5. J. Desai, A. S. Bandyopadhyay, and A. B. Kaul, "Dielectric boron nitride inks in a metal-insulator platform and its photoinduced capacitance modulation," manuscript in preparation, to be submitted, 2018.
6. S. Chugh, N. Adhikari, M. Min, L. Echegoyen, and A. B. Kaul, "Endohedral-doped graphene with ScN@C<sub>80</sub> and La@C<sub>82</sub> for a new class of optoelectronic devices," manuscript in preparation, to be submitted.
7. S. Chugh, A. S. Bandyopadhyay, R. Hossain, N. Adhikari, M. Min, L. Echegoyen, and A. B. Kaul, "Photo-induced electron transfer and exciton-trion dynamics in 0D-2D WSe<sub>2</sub> structures," manuscript in preparation, to be submitted.
8. J. Desai, A. S. Bandyopadhyay, D. Biswas, I. Mahbub, and A. B. Kaul, "Ink-jet printed hexagonal-boron nitride integrated with graphene in a microstrip transmission line configuration and its high-frequency response," manuscript in preparation, to be submitted, 2018.

9. S. Chugh, N. Adhikari, R. Hossain, M. Min, L. Echegoyen, and A. B. Kaul, "Probing charge carrier dynamics in quantum dots and Sc<sub>3</sub>N@C<sub>80</sub> endohedrals integrated with monolayer WSe<sub>2</sub>," manuscript in preparation, to be submitted.

## Published (Journal)

1. R. Hossain, I. Deaguero, T. Boland, and **A. B. Kaul**, "Large-format, biocompatible, ink-jet printed 2D-heterostructure photodetector on flexible substrates," *Nature npj 2D Materials and Applications Journal*, **1**(28) (2017); DOI: 10.1038/s41699-0170034-2.
2. M. Michel, C. Biswas, R. Hossain, C. Tiwary, P. M. Ajayan, and **A. B. Kaul**, "A thermally-invariant, high-power graphite resistor for flexible electronics formed using additive manufacturing," *2D Materials Journal (IOP)* **4**(2), 025076 (2017).
3. M. Michel, C. Biswas, and **A. B. Kaul**, "High-performance ink-jet printed graphene resistors formed with environmentally-friendly, surfactant-free inks for extreme thermal environments," *Applied Materials Today* **6**, 16 (2017).
4. J. A. Desai, C. Biswas, A. B. Kaul, "Inkjet printing of liquid-exfoliated, highly conducting graphene/poly(3,4 ethylenedioxythiophene): poly(styrene sulfonate) nanosheets for organic electronics," *J. Vacuum Sci. & Technol. B, Nanotechnology and Microelectronics: Materials, Processing, Measurement and Phenomena*, vol. 35, issue 3, 03D112, American Vacuum Society, 2017.
5. J. A. Catalan and A. B. Kaul, "Polydimethylsiloxane and polyisoprene-based graphene composites for strain-sensing," *J. Vacuum Sci. & Technol. B, Nanotechnology and Microelectronics: Materials, Processing, Measurement and Phenomena*, vol. 35, issue 3, 03D106, American Vacuum Society, 2017.
6. S. Chugh, C. Biswas, L. Echegoyen, and A. B. Kaul, "Investigation of structural morphology and electrical properties of graphene-C<sub>60</sub> hybrids," *J. Vacuum Sci. & Technol. B, Nanotechnology and Microelectronics: Materials, Processing, Measurement and Phenomena*, vol. 35, issue 3, 03D111, American Vacuum Society, 2017.

## CONFERENCE PUBLICATIONS & PROCEEDINGS ARTICLES

1. J. Catalan, R. Martinez, Y. Lin, and A. B. Kaul, "Electrical Characterization and Nano-indentation of Opto-electro-mechanical Percolative Composites From 2D Layered Materials," *MRS Advances*, vol. 2, issue 60 (Electronics and Photonics), pp. 3741-3747, 2017.
2. J. A. Desai, N. Adhikari, and A. B. Kaul, "Tungsten disulfide nanodispersions for inkjet printing and semiconducting devices," *MRS Advances*, vol. 2, issue 60 (Electronics and Photonics), pp. 3697-3702, 2017.

3. N. Adhikari, A. S. Bandyopadhyay, and A. B. Kaul “Nanoscale charge transport properties of perovskite solar cells with 2D materials for stable performance,”oral presentation, Solar Technologies Symposium, NanoTech 2017 Conference & Expo (part of Techconnect World Innovation Conference & Expo), National Harbor, MD May, 2017.

## **STUDENT RECOGNITIONS**

Ridwan Hossain (PhD candidate): 1<sup>st</sup> place in Graduate Student Expo, University of Texas, El Paso, Fall 2017